

# **ENVIRONMENTAL MONITORING WHILE DRILLING SENSOR DELIVERY SYSTEM**

## **TECHNOLOGY NEED**

Information on drill bit location, temperature, and subsurface conditions during drilling is required in many environmental restoration operations. An inexpensive data collection system for identifying and tracking contaminant concentrations and monitoring drill bit conditions is needed for many waste site operations. The Hanford tank farms need to be characterized below the tanks for the presence of cesium-137 and other contaminants. A two- or three-man crew probing underground to evaluate soil conditions with a steerable drilling sensor system could quickly map contamination zones, provide for field screening (i.e., the ability to "steer" in or out of contaminated zones), operate safely, and greatly reduce clean-up costs.

## **TECHNOLOGY DESCRIPTION**

The Environmental Monitoring While Drilling (EMWD) sensor delivery system represents an innovative blending of new and existing technology for obtaining real-time data during drilling. The long-term objective of this project is to distinguish contaminated from non-contaminated areas in real time while drilling beneath a hazardous waste site. The down-hole sensors are located behind the drill bit and linked by a high-speed data transmission system to a computer at the surface. As drilling is conducted, real-time data are collected on the nature and extent of contamination, thus enabling on-the-spot decisions regarding drilling and sampling strategies. The EMWD system has been adapted by the integration of a gamma ray spectrometer (GRS) in place of the simple gamma radiation detector originally used. The GRS consists of a sodium-iodide, thallium-activated crystal coupled to a photomultiplier tube (PMT). The GRS output feeds to a multichannel analyzer (MCA). The 256-channel MCA gamma spectrum (100 keV-1.6 MeV) data are transmitted to the surface via a signal conditioning and transmitter board. The system also monitors the up-hole battery voltage as measured down-hole, and the temperatures associated with the detector and instrumentation. The EMWD design includes data assurance techniques to increase safety by reducing the probability of giving a safe indication when an unsafe condition exists.

The system provides real-time data on an eight differential, single-analog multiplexer and any number of digital channels. Sampling speed from the analog channels can reach 100 kHz. The telemetry system is firmware programmable to easily support many different data formats and additional data channels. The data transmission format (digital FM bi-phase, 4800 baud) provides excellent noise rejection for jumping the wireless connection between the rotating drill pipe and the stationary receiver. A Sandia-designed receiver removes the FM carrier generating the data clock, and buffers data to be used by an IBM or compatible personal computer. A 28V rechargeable battery pack can supply down-hole instrumentation power for more than 18 hours of drilling. The battery pack remains on top for easy maintenance and/or recharging.

Preliminary field tests were successfully completed at the radioactive calibration facility in Grants, New Mexico, at Sandia National Laboratory in Albuquerque, New Mexico, and at the Charles Machine Works, Inc. (CMW) directional boring test site. The EMWD gamma ray spectrometer (EMWD-GRS) system was field-demonstrated at Westinghouse Savannah River Site F-Area Retention Basin in April 1996. Phase I of the demonstration determined radiological background. Phase II of the "hot site" demonstration continuously monitored for gamma activity in real time while drilling two boreholes. Contaminant levels of cesium-137 recorded by the EMWD-GRS during drilling agree with contaminant levels previously determined through quantitative laboratory analysis of soil samples. In addition, previously unidentified gamma radiation "hot spots" were identified. The successful demonstration resulted in no radiation-contaminated equipment or waste. The EMWD-GRS with an orientation sensor package was tested in a non-contaminated "cold site" demonstration. There were no problems taking the orientation sensor package data along with the gamma spectrometer data. The preliminary results from this test are encouraging.

The EMWD sensor delivery system can be used in site characterization for contaminant detection and delineation. This will allow for appropriate sampling activities and guide borehole emplacement options (i.e., a drill operator can back out of contaminated soils and redirect a drilling operation around the contamination). Other potential users of EMWD include utility emplacement and petroleum industries.

## **BENEFITS**

There are time, cost, and safety advantages to using the EMWD field screening approach:

- Data on the nature of contamination will be available in minutes (as opposed to weeks or months from an off-site laboratory).
- Field screening while drilling can reduce the number of costly drilling operations.
- Substantial cost savings will result from minimizing the number of samples required for off-site confirmatory analyses.
- Worker safety will be enhanced as a result of minimizing waste generation and by quickly alerting field personnel to potentially hazardous conditions.

## **CAPABILITIES/LIMITATIONS**

The EMWD system is compatible with directional drilling techniques that use minimal drilling fluids and generate little-to-no secondary waste. The current system includes a continuous readout, non-walk-over guidance and location capabilities. The orientation sensor package was integrated with the EMWD-GRS system without significant modification. Sensors are also needed for the detection of heavy metals, volatile organic compounds, and natural gas.

## **COLLABORATION/TECHNOLOGY TRANSFER**

The EMWD program collaborated with the DOE Environmental Restoration (EM-40) at WSRC to conduct a demonstration of the GRS-EMWD tool at the WSRS F-Area Retention Basin. Charles Machine Works is the Sandia National Laboratories (SNL) industrial partner. SNL Technology Transfer is in negotiations with Charles Machine Works, Inc., for the licensing of the cable coil. They are seeking an exclusive license in all fields of use. SNL expects to have a signed agreement in May-June 1998. SNL has received a letter of commitment from the Hanford Vadose Zone Program to support an EMWD 'hot site' demonstration at the SX Tank Farm. Should the planned demonstration show that it would be feasible to deploy EMWD technology in Hanford tank farm soils, Hanford anticipates deploying this technology in the tank farm vadose zone for its FY 1999 characterization activities. Over one thousand requests have been received for the performance data from this demonstration and the results will be provided to all requestors.

## **ACCOMPLISHMENTS**

### **FY 1996 Accomplishments:**

- The Geiger Mueller Tube (GMT) EMWD tool was successfully tested in the laboratory and in the field at the Charles Machine Works Directional Drilling Range.
- The Gamma Spectroscopy EMWD tool is also fully operational and was field-tested at the Charles Machine Works Directional Drilling Range.
- Sandia National Laboratories and Westinghouse Savannah River Company (WSRC) completed the Cost-Integrated Contractor Order (CICO) Statement of Work (SOW) for conducting a demonstration of the GRS-EMWD at the Savannah River Site (SRS).
- The test plan and work plan for the GRS-EMWD Demonstration at the F-Area Retention Basin was reviewed and accepted by WSRC. The directional drilling for this demonstration was conducted by Geneva Corporation using equipment from Ditch Witch of Georgia. The purpose of the demonstration was to evaluate the radionuclide concentration data collected in real time while drilling using the GRS-EMWD tool against the radionuclide concentration data obtained from the off-site soil samples.

Two boreholes were directionally drilled through the F-Area Retention Basin to intersect previous soil sample locations (FRB-05, -06, -07, and -08) and adjacent to another soil sample location (FRB-19). We detected and quantified the gamma radiation emitting contamination at the sites previously known. In addition, we identified two new gamma radiation "hot spots." The pull back of the drill rod was successful in that no radiation contaminated equipment or waste was produced.

#### **FY 1997 Accomplishments:**

- The EMWD system has been improved by the integration of a magnetometer and a miniature angular-orientation sensor. This added capability gives precise positioning information by providing pitch, roll, and azimuth. Additionally, three accelerometers were integrated into the package. This added capability provides us with pitch and roll information that is redundant to that from the magnetometer.
- "Final Report on the Environmental Measurement While Drilling Gamma Ray Spectrometer System Technology Demonstration at the Savannah River Site F-Area Retention Basin." SAND97-2028 was published.

#### **FY 1998 Accomplishments:**

- Chapter I of the patent application was completed to address the requirements of the Patent Cooperation Treaty (PCT); Chapter I of the patent application protects the coaxial cable coil patent from foreign filing. Chapter I of the patent application contains the results of a search to determine if the inventions are patentable. A favorable report has been received from the PCT examiner. PCT, Chapter II, which is an examination of the patent application that results in an examination report, has also been complete.
- The modified EMWD system including the magnetometer, an array of three accelerometers, and a continuous distance measurement capability were successfully demonstrated at the Charles Machine Works, Inc., testing range. A U.S. Patent 5722488: Apparatus for Down-Hole Drilling Communications and Method for Making and Using the Same was issued on March 3, 1998, for the EMWD cable coil.
- A software copyright application is being filed for the protection of the SNL-written Decom software that is used in the EMWD system. Decom is a Windows-based software that is used for data reduction, storage, and display.

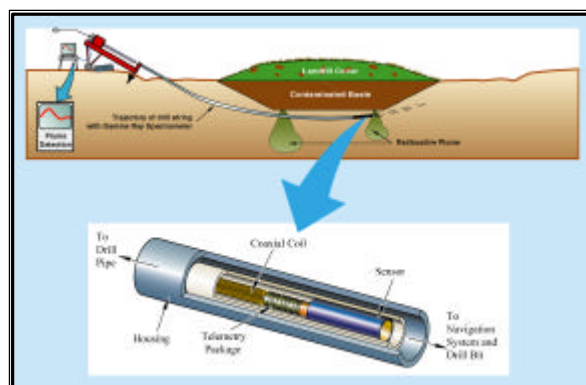
### **TECHNICAL TASK PLAN (TTP) INFORMATION**

TTP No./Title: AL27C221 - New Environmental Measurement While Drilling

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**Real-time data analysis and more sensors are enhancing the capabilities and performance of subsurface monitoring while drilling.**